Module Handbook

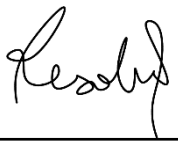
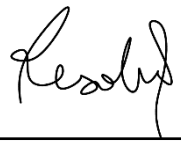
Biomodelling

Bachelor Degree Program
Department of Biomedical Engineering

Faculty of Intelligent Electrical Technology and Informatics
Institut Teknologi Sepuluh Nopember

MODULE HANDBOOK
BIOMODELLING
DEPARTMENT OF BIOMEDICAL ENGINEERING
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
Number : 6825/IT2.IX.5.1.2/B/PP.03.00.00/2023

ENDORSEMENT PAGE

Proses ***Process***	**Penanggung Jawab** ***Person in Charge***			**Tanggal** ***Date***
	Nama ***Name***	**Jabatan** ***Position***	**Tandatangan** ***Signature***	
Perumus *Preparation*	Nada Fitrieyatul Hikmah, S.T., M.T.	Dosen *Lecturer*		**November 18, 2022**
Pemeriksa dan Pengendalian *Review and Control*	Dr. Achmad Arifin, S.T., M.Eng.	Tim kurikulum *Curriculum team*		**November 20, 2022**
Persetujuan *Approval*	Dr. Rachmad Setiawan, S.T., M.T.	Koordinator RMK *Course Cluster Coordinator*		**April 13, 2023**
Penetapan *Determination*	Dr. Achmad Arifin, S.T., M.Eng.	Kepala Departemen *Head of Department*		**April 17, 2023**

MODULE HANDBOOK
BIOMODELLING

Module name	**Biomodelling**	
Module level	Undergraduate	
Code	EB234506	
Course (if applicable)	Biomodelling	
Semester	V	
Person responsible for the module	Fauzan Arrofiqi, S.T., M.T., Ph.D.	
Lecturer	Dr. Achmad Arifin, S.T., M.Eng. Nada Fitrieyatul Hikmah, S.T, M.T. Eko Agus Suprayitno, S.Si., M.T.	
Language	Bahasa Indonesia and English	
Relation to curriculum	Undergradute degree program, **mandatory**, 5th semester.	
Type of teaching, contact hours	Lectures, <60 students	
Workload	1. Lectures : 3 x 50 = 150 minutes per week. 2. Exercises and Assignments : 3 x 60 = 180 minutes (3 hours) per week. 3. Private learning : 3 x 60 = 180 minutes (3 hours) per week.	
Credit points	3 credit points (sks)	
Requirements according to the examination regulations	A student must have attended at least 75% of the lectures to sit in the exams.	
Mandatory prerequisites	EB234304 Fundamentals of Signal Processing EB234402 Fundamentals of Control Systems and Laboratory	
Learning outcomes and their corresponding PLOs	Course Learning Outcome (CLO) after completing this module, CLO 1: Students are able to understand the basics of modeling the physiological system of the human body and its limitations. CLO 2: Students are able to apply science concepts to model physiological systems, particularly in the cardiovascular system. CLO 3: Students are able to perform dynamic analysis and modeling for ECG.	PLO-05 PLO-05 PLO-05

	CLO 4: Students are able to apply the linear prediction method for modeling sound signals. CLO 5: Students understand the concept of a 3D coordinate system and its use in deriving the motion equation. CLO 6: Students are able to realize 3D programming for the application of modeling the human body physiology system. CLO 7: Students are able to understand muscular modeling in biomechanical computation.	PLO-05 PLO-06 PLO-11 PLO-02
Content	The Biomodeling course is a compulsory subject required to learn about the technique of modeling the human body physiology system based on the characteristics of the physiological system. This course aims to enable students to understand biological functions and apply scientific concepts to model physiological systems. Based on this understanding and analytical skills, students can also use it in the biomedical engineering discipline.	
Study and examination requirements and forms of examination	● In-class exercises ● Assignment 1, 2, 3 ● Mid-term examination ● Final examination	
Media employed	LCD, whiteboard, websites (myITS Classroom), zoom.	
Reading list	1. Marmarelis, V.Z., 2004, “Nonlinear Dynamic Modeling of Physiological System”, John Wiley & Sons, Inc. 2. Rideout, V.C., 1991, “Mathematical and Computer Modeling of Physiological Systems”, Prentice-Hall Inc. 3. Vaseghi, S.V., 2008, “Advanced Digital Signal Processing and Noise Reduction, Fourth Edition”, John Wiley & Sons, Inc. 4. McSharry, P.E., Clifford, G.D., Tarassenko, L., and Smith, L.A., 2003, “A Dynamical Model for Generating Synthetic Electrocardiogram Signals”, *IEEE Transaction on Biomedical Engineering*, Vol. 50, No. 3, pp. 289-294.	

I. Rencana Pembelajaran Semester / *Semester Learning Plan*

	INSTITUT TEKNOLOGI SEPULUH NOPEMBER (ITS) **FAKULTAS TEKNOLOGI ELEKTRO DAN INFORMATIKA CERDAS** **DEPARTEMEN TEKNIK BIOMEDIK**						**Kode Dokumen**
RENCANA PEMBELAJARAN SEMESTER							
MATA KULIAH (MK) ***COURSE***	**KODE** ***CODE***	**Rumpun MK** ***Course Cluster***	**BOBOT (sks)** ***CREDITS***		**SEMESTER**	**Tgl Penyusunan** ***Compilation Date***	
Biomodeling	EB234506	Teknik Biomedik *Biomedical Engineering*	T=3	P=0	V	Nov 9, 2022	
OTORISASI / PENGESAHAN ***AUTHORIZATION / ENDORSEMENT***	**Dosen Pengembang RPS** ***Developer Lecturer of Semester Learning Plan***		**Koordinator RMK** ***Course Cluster Coordinator***		**Ka DEPARTEMEN** ***Head of Department***		
	(Fauzan Arrofiqi, S.T., M.T., Ph.D.)		**(Ir. Josaphat Pramudianto, M.Eng)**		**(Dr. Achmad Arifin, S.T., M.Eng.)**		
Capaian Pembelajaran ***Learning Outcomes***	**CPL-PRODI yang dibebankan pada MK** ***PLO Program Charged to The Course***						
	CPL-02 ***PLO-02***	Mampu **menerapkan** ilmu pengetahuan, keterampilan, dan metode terkini dalam menyelesaikan permasalahan di bidang Teknik Biomedika. *Able to **apply** the latest knowledge, skills and methods in solving problems in the field of Biomedical Engineering*					
	CPL-05 ***PLO-05***	Mampu **menemukan**, **memahami**, **menjelaskan**, **merumuskan**, dan **menyelesaikan** permasalahan umum pada bidang Teknik dan permasalahan khusus pada bidang Teknik Biomedika yang meliputi instrumentasi biomedika cerdas, teknik rehabilitasi medika, pencitraan dan pengolahan citra medika, serta informatika medika. *Able to **find**, **understand**, **explain**, **formulate**, and **solve** general problems in the field of Engineering and special problems in the field of Biomedical Engineering which includes intelligent biomedical instrumentation, medical rehabilitation techniques, imaging and processing of medical images, and medical informatics*					

	CPL-06 ***PLO-06***	Mampu **merancang** dan **melaksanakan** eksperimen laboratorium dan/atau lapangan, menganalisa dan menginterpretasi data, serta menggunakan penilaian yang obyektif untuk menarik kesimpulan *Able to **design** and **implement** laboratory experiment and / or field experiments, analyze and interpret data, and use objective assessments to draw conclusions.*
	CPL-11 ***PLO-11***	Mampu **mengetahui/mengikuti** perkembangan terkini dibidang ilmu pengetahuan dan teknologi serta **menyikapinya secara obyektif** dengan mengedepankan nilai-nilai kebenaran universal. *Able to **know/follow** the latest developments in the field of science and technology and to **react objectively** by promoting the values of universal truth*
	Capaian Pembelajaran Mata Kuliah (CPMK) – Bila CP MK sebagai kemampuan pada tiap tahap pembelajaran CP MK = Sub CP MK ***Course Learning Outcome (CLO) - If CLO as description capability of each Learning Stage in the course, then CLO = LLO***	
	CP MK 1 ***CLO 1***	Mahasiswa mampu memahami dasar pemodelan sistem fisiologi tubuh manusia dan limitasinya. *Students are able to understand the basics of modeling the physiological system of the human body and its limitations.*
	CP MK 2 ***CLO 2***	Mahasiswa mampu menerapkan konsep sains untuk memodelkan sistem fisiologi, terutama pada sistem kardiovaskular. *Students are able to apply science concepts to model physiological systems, particularly in the cardiovascular system.*
	CP MK 3 ***CLO 3***	Mahasiswa mampu melakukan analisis dan pemodelan dinamis untuk ECG. *Students are able to perform dynamic analysis and modeling for ECG.*
	CP MK 4 ***CLO 4***	Mahasiswa mampu menerapkan metode linier prediction untuk pemodelan sinyal suara. *Students are able to apply the linear prediction method for modeling sound signals.*
	CP MK 5 ***CLO 5***	Mahasiswa memahami konsep sistem koordinat 3D dan penggunaannya dalam menurunkan motion equation. *Students understand the concept of a 3D coordinate system and its use in deriving the motion equation.*
	CP MK 6 ***CLO 6***	Mahasiswa mampu merealisasikan pemrograman 3D untuk aplikasi pemodelan sistem fisiologi tubuh manusia. *Students are able to realize 3D programming for the application of modeling the human body physiology system.*
	CP MK 7 ***CLO 7***	Mahasiswa mampu memahami pemodelan muscular dalam komputasi biomekanika. *Students are able to understand muscular modeling in biomechanical computation.*

Peta CPL – CP MK

Map of PLO - CLO

	CPL-01	CPL-02	CPL-03	CPL-04	CPL-05	CPL-06	CPL-07	CPL-08	CPL-09	CPL-10	CPL-11	CPL-12
CPMK 1 / SUB CPMK 1 *CLO 1 / LLO 1*					√							
CPMK 2 / SUB CPMK 2 *CLO 2 / LLO 2*					√							
CPMK 3 / SUB CPMK 3 *CLO 3 / LLO 3*					√							
CPMK 4 / SUB CPMK 4 *CLO 4 / LLO 4*					√							
CPMK 5 / SUB CPMK 5 *CLO 5 / LLO 5*						√					√	
CPMK 6 / SUB CPMK 6 *CLO 6 / LLO 6*						√					√	
CPMK 7 / SUB CPMK 7 *CLO 7 / LLO 7*		√										

Diskripsi Singkat MK

Mata kuliah Biomodeling merupakan mata kuliah wajib yang diperlukan untuk mempelajari mengenai teknik pemodelan sistem fisiologi tubuh manusia berdasarkan karakteristik dari sistem fisiologi tersebut. Mata kuliah ini bertujuan agar mahasiswa mampu memahami fungsi biologi dan menerapkan konsep sains untuk memodelkan sistem fisiologi. Berdasarkan pemahaman dan kemampuan analisis tersebut, mahasiswa juga dapat memanfaatkannya dalam disiplin ilmu teknik biomedik.

Short Description of Course

The Biomodeling course is a compulsory subject required to learn about the technique of modeling the human body physiology system based on the characteristics of the physiological system. This course aims to enable students to understand biological functions and apply scientific concepts to model physiological systems. Based on this understanding and analytical skills, students can also use it in the biomedical engineering discipline.

Bahan Kajian:
Materi pembelajaran

Course Materials:

1. Konsep Biomodelling / *Biomodelling Concept*
2. Pemodelan sistem kardiovaskular / *Cardiovascular system modeling*
3. Model dinamis untuk ECG / *Dynamic model for ECG*
4. Linear Prediction Coding / *Linear Prediction Coding*
5. 3D Programming / *3D Programming*
6. Pemodelan sistem gerak / *Modeling of motion systems*

	7. Pemodelan otot / *Muscle modeling*
Pustaka ***References***	**Utama / *Main* :** 1. Marmarelis, V.Z., 2004, "Nonlinear Dynamic Modeling of Physiological System", John Wiley & Sons, Inc. 2. Rideout, V.C., 1991, "Mathematical and Computer Modeling of Physiological Systems", Prentice-Hall Inc. 3. McSharry, P.E., Clifford, G.D., Tarassenko, L., and Smith, L.A., 2003, "A Dynamical Model for Generating Synthetic Electrocardiogram Signals", *IEEE Transaction on Biomedical Engineering*, Vol. 50, No. 3, pp. 289-294. **Pendukung / *Supporting*:** 4. Vaseghi, S.V., 2008, "Advanced Digital Signal Processing and Noise Reduction, Fourth Edition", John Wiley & Sons, Inc.
Dosen Pengampu ***Lecturers***	Dr. Achmad Arifin, S.T., M.Eng. Nada Fitrieyatul Hikmah, S.T, M.T. Eko Agus Suprayitno, S.Si., M.T.
Mata kuliah syarat ***Prerequisite***	EB234304 Dasar Pengolahan Sinyal EB234402 Dasar Sistem Pengaturan dan Laboratorium *EB234304 Fundamentals of Signal Processing* *EB234402 Fundamentals of Control Systems and Laboratory*

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)		
(1)	(2)	(3)	(4)			(7)	(8)
1	Mahasiswa mampu memahami dasar pemodelan sistem fisiologi tubuh manusia dan limitasinya. *Students are able to understand the basics of modeling the physiological system of the human body and its limitations.*	• Mampu mendefinisikan tujuan dan desain dari pemodelan secara umum • Mampu menjelaskan tantangan membuat model ideal pada sistem fisiologi • Mampu membuat blok pemodelan berdasarkan model specification • *Able to define the objectives and design of modeling in general* • *Able to explain the challenges of making*	Diskusi dan tanya jawab. **Tes:** Soal ETS (masuk dalam penilaian ETS) *Discussion and questions and answers.* ***Test:*** *Mid-term examination questions (included in the mid-term assessment)*	• Kuliah dan brainstorming, tanya jawab [TM : 1x3x50”] [BM : 1x3x60”] [PT : 1x3x60”] • *Presentation and brainstorming, question and answer.* *[FF : 1x3x50”]* *[SA : 1x3x60”]* *[SS : 1x3x60”]*	• Chatting dan diskusi dalam forum platform ITS • *Chat and discussion in ITS platform forum.*	• Kontrak kuliah: - Motivasi belajar - Rencana pembelajaran - Aturan-aturan perkuliahan - Tujuan perkuliahan - Sistem penilaian, buku ajar/sumber pustaka • Modeling process • Model design • Physiology modelling • Model specification • Model estimation	

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)	(7)	(8)
		ideal models of physiological systems ● *Able to make modeling blocks based on specification models*				● *Course contract:* *- Motivation to learn* *- Lesson plan* *- Lecture rules* *- Course objective* *- Assessment system, textbooks / library resources* ● *Modeling process* ● *Model design* ● *Physiology modelling* ● *Model specification* ● *Model estimation*	
2	Mahasiswa mampu menerapkan konsep sains untuk memodelkan sistem fisiologi, terutama pada sistem kardiovaskular.	● Mampu membedakan pemodelan white box, black box, dan grey box. ● Mampu memahami perkembangan konsep	**Non-tes:** **Tugas 1 tahap 1:** Melakukan pemodelan sistem pembuluh darah	● Kuliah, diskusi, tanya jawab, tugas [TM : 1x3x50”] [BM : 1x3x60”]		● *White, black, grey box* ● *Lumped parameter* ● *Distributed parameter*	**2.5**

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)	(7)	(8)
	Students are able to apply science concepts to model physiological systems, particularly in the cardiovascular system.	pemodelan pada pembuluh darah dari 0D hingga 3D. ● Mampu melakukan pemodelan pembuluh darah dengan analogi rangkaian listrik. ● *Able to distinguish between white box, black box and gray box modeling.* ● *Able to understand the development of modeling concepts in blood vessels from 0D to 3D.* ● *Able to perform blood vessel modeling by analogy to electrical circuits.*	dengan analogi rangkaian listrik **Tes:** Soal ETS (masuk dalam penilaian ETS) ***Non-test:*** ***Task 1 stage 1:*** *Perform modeling of the vascular system using an electrical circuit analogy* ***Test:*** *Mid-term examination questions (included in the mid-term assessment)*	[PT : 1x3x60”] ● *Lecture, discussion, question and answer, exercise and assignment* *[FF : 1x3x50”]* *[SA : 1x3x60”]* *[SS : 1x3x60”]*		● *Mapping cardiovascular element to electrical element* ● *Windkessel model*	

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)	(7)	(8)
3 - 4	Mahasiswa mampu melakukan analisis dan pemodelan dinamis untuk ECG. *Students are able to perform dynamic analysis and modeling for ECG.*	• Mampu menjelaskan proses fisiologi dari morfologi gelombang pada sinyal ECG. • Mampu mendefinisikan fungsi parameter yang berkaitan dengan pemodelan. • Mampu menjelaskan dan mengaplikasikan algoritma untuk pemodelan dinamis ECG. • *Able to explain the physiological processes of wave morphology in ECG signals.*	**Non-tes :** **Tugas 1 tahap 2:** Melakukan komputasi dan analisis terhadap model dinamis sinyal ECG **Tes :** Soal ETS (masuk dalam penilaian ETS) ***Non-test:*** ***Task 1 stage 2:*** *Perform computation and analysis of the dynamic model of the ECG signal* ***Test:***		• Kuliah, diskusi, tanya jawab, tugas dalam platform myITS Classroom [TM : 2x3x50”] [BM : 2x3x60”] [PT : 2x3x60”] • *Lecture, discussion, question and answer, exercise and assignment [FF : 2x3x50”] [SA : 2x3x60”] [SS : 2x3x60”]*	• Fisiologi morfologi ECG • Karakteristik spectral • Morphological parameter • State space • *Physiology of ECG morphology* • *Spectral characteristics* • *Morphological parameters* • *State space*	**5**

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)	(7)	(8)
		• *Able to define parameter functions related to modeling.* • *Able to explain and apply algorithms for dynamic ECG modeling.*	*Mid-term examination questions (included in the mid-term assessment)*				
5-7	Mahasiswa mampu menerapkan metode linier prediction untuk pemodelan sinyal suara. *Students are able to apply the linear prediction method for modeling sound signals.*	• Mampu mengaplikasikan trajectory prediction untuk memodelkan spektrum dari sinyal. • Mampu melakukan komputasi untuk mengambil data sinyal suara. • Mampu memodelkan sinyal suara dengan metode linier prediction	**Non-tes:** **Tugas 2:** Melakukan komputasi linear prediction model dengan masukan sinyal suara. **Tes:** Soal ETS (masuk dalam penilaian ETS) ***Non-test:*** ***Task 2:***	• Kuliah, diskusi, tanya jawab, tugas [TM : 3x3x50”] [BM : 3x3x60”] [PT : 3x3x60”] • *Lecture, discussion, question and answer, exercise and assignment*		• Linier prediction coding • Predictor cofficient • Restorasi sinyal domain frekuensi • *Linear prediction coding* • *Predictor coefficient* • *Frequency domain signal restoration*	**7.5**

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment;* *[Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material* *[Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)	(7)	(8)
		• *Able to apply trajectory prediction to model the spectrum of signals.* • *Able to perform computations to retrieve voice signal data.* • *Able to model voice signal using linear prediction method*	*Computing the linear prediction model with voice signal input.* ***Test:*** *Mid-term examination questions (included in the mid-term assessment)*	*[FF : 3x3x50”]* *[SA : 3x3x60”]* *[SS : 3x3x60”]*			
8	**EVALUASI TENGAH SEMESTER** ***MID-SEMESTER EXAM***						**35**
9	Mahasiswa memahami konsep sistem koordinat 3D dan penggunaannya dalam menurunkan motion equation. *Students understand the concept of a 3D coordinate*	• Mampu memahami konsep sistem koordinat 3D. • Mampu menggunakan sistem koordinat 3D dalam menurunkan persamaan gerak.	**Tes :** Soal EAS (masuk dalam penilaian ETS) ***Test:*** *Final examination questions (included*	• Kuliah, diskusi, tanya jawab, tugas [TM : 1x3x50”] [BM : 1x3x60”] [PT : 1x3x60”]		• *Numerical Integration* • *Motion Equation* • *Coordynate system to motion equation*	

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)	(7)	(8)
	system and its use in deriving the motion equation.	• Mampu menggunakan OpenGL untuk pemrograman 3D. • *Able to understand the concept of the 3D coordinate system.* • *Able to use a 3D coordinate system in deriving equations of motion.* • *Able to use OpenGL for 3D programming.*	*in the mid-term assessment)*	• *Lecture, discussion, question and answer, exercise and assignment* *[FF : 1x3x50”]* *[SA : 1x3x60”]* *[SS : 1x3x60”]*			
10 -12	Mahasiswa mampu merealisasikan pemrograman 3D untuk aplikasi pemodelan sistem fisiologi tubuh manusia.	• Mampu merealisasikan 3D programming dengan memanfaatkan OpenGL • Mampu mengaplikasikan Human Machine	**Non-tes :** **Tugas 3 tahap 1:** Melakukan komputasi dan analisis sesuai tugas human movement model yang diarahkan	• Kuliah, diskusi, tanya jawab, tugas [TM : 3x3x50”] [BM : 3x3x60”] [PT : 3x3x60”]		• *OpenGL* • *3D programming* • *Human Machine Interaction* • *Human movement model*	**10**

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)	(7)	(8)
	Students are able to realize 3D programming for the application of modeling the human body physiology system.	Interaction pada pemodelan untuk 3D programming ● *Able to realize 3D programming by using OpenGL* ● *Able to apply Human Machine Interaction in modeling for 3D programming*	untuk pemodelan fisiologi tubuh manusia. **Tes :** Soal EAS (masuk dalam penilaian EAS) ***Non-test:*** ***Task 3 stage 1:*** *Perform computation and analysis according to the task of the human movement model which is directed at modeling the physiology of the human body.*	● *Lecture, discussion, question and answer, exercise and assignment* *[FF : 3x3x50”]* *[SA : 3x3x60”]* *[SS : 3x3x60”]*			

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)	(7)	(8)
			Test: *Final examination questions (included in the mid-term assessment)*				
13-14	Mahasiswa mampu memahami pemodelan muscular dalam komputasi biomekanika. *Students are able to understand muscular modeling in biomechanical computation.*	• Mampu memahami muscle modeling berdasarkan Hill Type Muscle model. • Mampu merealisasikan Hill Muscle model dalam komputasi biomekanika • *Able to understand muscle modeling based on Hill Type Muscle model.* • *Able to realize Hill Muscle model in*	**Non-tes :** **Tugas 3 tahap 2:** Menyusun program simulasi untuk muscle force **Tes :** Soal EAS (masuk dalam penilaian EAS) ***Non-test:*** ***Task 3 stage 2:*** *Develop a simulation program for muscle force* ***Test:***	• Kuliah, diskusi, tanya jawab, tugas [TM : 2x3x50”] [BM : 2x3x60”] [PT : 2x3x60”] • *Lecture, discussion, question and answer, exercise and assignment* *[FF : 2x3x50”]* *[SA : 2x3x60”]*		• *Muscle mechanics effect of stretch and shortening on skeletal force* • *Fisiologi otot* • *Muscle modelling* • *Hill type muscle model*	**10**

Mg Ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian (%) / *Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*	Tatap Muka (5) / *In-class* (5)	Daring (6) / *Online* (6)		
(1)	(2)	(3)	(4)			(7)	(8)
		biomechanical computation	*Final examination questions (included in the mid-term assessment)*	*[SS : 2x3x60"]*			
15-16	**EVALUASI AKHIR SEMESTER** *FINAL-SEMESTER EXAM*						**30**

TM=Tatap Muka, **PT**=Penugasan Terstuktur, **BM**=Belajar Mandiri.

II. Rencana Asesmen & Evaluasi (RAE) / *Assessment & Evaluation Plan*

	ASSESSMENT & EVALUATION PLAN BACHELOR DEGREE PROGRAM OF BIOMEDICAL ENGINEERING - FTEIC ITS **Course : Biomodelling**		**RA&E** Write Doc Code
Kode / Code: **EB234506**	**Bobot sks / Credits (T/P): 3/0**	**Rumpun MK: Teknik Biomedik** ***Course Cluster: Biomedical Engineering***	Smt: 5
OTORISASI ***AUTHORIZATION***	**Penyusun RA & E** ***Compiler A&EP*** **Nada Fitrieyatul H, S.T, M.T**	**Koordinator RMK** ***Course Cluster Coordinator*** **Ir. Josaphat Pramudianto, M.Eng**	**Ka DEP** ***Head of DEP*** **Dr. Norma Hermawan, S.T., M.T., M.Sc.**

Mg ke / *Week* (1)	**Sub CP-MK / *Lesson Learning Outcomes (LLO)* (2)**	**Bentuk Asesmen (Penilaian) *Form of Assessment* (3)**	**Bobot / *Load* (%) (4)**
1	**Sub CP-MK 1:** Mahasiswa mampu memahami dasar pemodelan sistem fisiologi tubuh manusia dan limitasinya. ***LLO 1:*** *Students are able to understand the basics of modeling the human body physiology system and its limitations.*	**Tes :** ETS Soal 1 (3% dari ETS 35%) ***Test:*** *Mid-term examination question 1 (3% of 35% ETS)*	
2	**Sub CP-MK 2:** Mahasiswa mampu menerapkan konsep sains untuk memodelkan sistem fisiologi, terutama pada sistem kardiovaskular. ***LLO 2:***	**Non-tes:** **Tugas 1 tahap 1:** Melakukan pemodelan sistem pembuluh darah dengan analogi rangkaian listrik **Tes:** ETS Soal 2 (7% dari ETS 35%) ***Non-test:*** ***Task 1 stage 1:***	2.5

Mg ke / *Week* (1)	Sub CP-MK / *Lesson Learning Outcomes (LLO)* (2)	Bentuk Asesmen (Penilaian) *Form of Assessment* (3)	Bobot / *Load* (%) (4)
	Students are able to apply science concepts to model physiological systems, particularly in the cardiovascular system.	*Perform modeling of the vascular system using an electrical circuit analogy* ***Test:*** *Mid-term examination question 2 (7% of 35% ETS)*	
3	**Sub CP-MK 3:** Mahasiswa mampu melakukan analisis dan pemodelan dinamis untuk ECG. ***LLO 3:*** *Students are able to perform dynamic analysis and modeling for ECG.*	**Non-tes :** **Tugas 1 tahap 2:** Melakukan komputasi dan analisis terhadap model dinamis sinyal ECG **Tes:** ETS Soal 3 (10% dari ETS 35%) ***Non-test:*** ***Task 1 stage 2:*** *Perform computation and analysis of the dynamic model of the ECG signal* ***Test:*** *Mid-term examination question 3 (10% of 35% ETS)*	5
6	**Sub CP-MK 4:** Mahasiswa mampu menerapkan metode linier prediction untuk pemodelan sinyal suara. ***LLO 4:*** *Students are able to apply the linear prediction method for modeling sound signals.*	**Non-tes:** **Tugas 2:** Melakukan komputasi linear prediction model dengan masukan sinyal suara. **Tes:** ETS Soal 4 (15% dari ETS 35%) ***Non-test:*** ***Task 2:*** *Computing the linear prediction model with voice signal input* ***Test:*** *Mid-term examination question 4 (15% of 35% ETS)*	7.5
8	**Evaluasi Tengah Semester** ***Mid-Term Exam***	**Tes:** Ujian Tulis/Ujian Daring ***Test:*** *Written Exams/Online Examinations*	35
9	**Sub CP-MK 5:** Mahasiswa memahami konsep sistem koordinat 3D	**Tes :** EAS Soal 1 (10% dari EAS 30%) ***Test:*** *Final examination question 1 (10% of 30% EAS)*	

Mg ke / *Week* (1)	Sub CP-MK / *Lesson Learning Outcomes (LLO)* (2)	Bentuk Asesmen (Penilaian) *Form of Assessment* (3)	Bobot / *Load* (%) (4)
	dan penggunaannya dalam menurunkan motion equation. ***LLO 5:*** *Students understand the concept of a 3D coordinate system and its use in deriving the motion equation.*		
11	**Sub CP-MK 6:** Mahasiswa mampu merealisasikan pemrograman 3D untuk aplikasi pemodelan sistem fisiologi tubuh manusia. ***LLO 6:*** *Students are able to realize 3D programming for the application of modeling the human body physiology system.*	**Non-tes:** **Tugas 3 tahap 1:** Melakukan komputasi dan analisis sesuai tugas human movement model yang diarahkan untuk pemodelan fisiologi tubuh manusia. **Tes:** EAS Soal 2 (10% dari EAS 30%) ***Non-test:*** ***Task 3 stage 1:*** *Perform computation and analysis according to the task of the human movement model which is directed at modeling the physiology of the human body.* ***Test:*** *Final examination question 2 (10% of 30% EAS)*	10
13	**Sub CP-MK 7:** Mahasiswa mampu memahami pemodelan muscular dalam komputasi biomekanika. ***LLO 7:*** *Students are able to understand muscular modeling in*	**Non-tes:** **Tugas 3 tahap 2:** Menyusun program simulasi untuk muscle force **Tes:** EAS Soal 3 (10% dari EAS 30%) ***Non-test:*** ***Task 3 stage 2:*** *Develop a simulation program for muscle force* ***Test:*** *Final examination question 3 (10% of 30% EAS)*	10

Mg ke / *Week* (1)	Sub CP-MK / *Lesson Learning Outcomes (LLO)* (2)	Bentuk Asesmen (Penilaian) *Form of Assessment* (3)	Bobot / *Load* (%) (4)
	biomechanical computation.		
16	**Evaluasi Akhir Semester** ***Final Exam***	**Tes:** Ujian Tulis/Ujian Daring **Test:** *Written Exams/Online Examinations*	30
		Total bobot penilaian ***Total assessment load***	**100%**

Indikator Pencapaian CPL Pada MK / *Indicator of PLO achievement charged to the course*

CPL yang dibebankan pada MK / *PLO charged to the course*	**CPMK / *Course Learning Outcome (CLO)***	**Minggu ke / *Week***	**Bentuk Asesmen / *Form of Assessment***	**Bobot / *Load* (%)**
CPL-02 / *PLO-02*	CPMK 7 / *CLO 7*	*Week- 11-15*	*Programming Assignment 3*	5
		Week- 16	*Final Exam Question 3*	15
CPL-05 / *PLO-05*	CPMK 1 / *CLO 1*	*Week- 2-5*	*Programming Assignment 1*	3
	CPMK 2 / *CLO 2*	*Week- 2-5*	*Programming Assignment 1*	5
		Week- 8	*Mid Exam Question 1*	4.5
	CPMK 3 / *CLO 3*	*Week- 6-7*	*Programming Assignment 2*	5
		Week- 8	*Mid Exam Question 2*	10
	CPMK 4 / *CLO 4*	*Week- 6-7*	*Programming Assignment 2*	7
		Week- 8	*Mid Exam Question 3*	10.5
		Week- 11-15	*Programming Assignment 3*	5
CPL-06 / *PLO-06*	CPMK 5 / *CLO 5*	*Week- 16*	*Final Exam Question 1*	5
	CPMK 6 / *CLO 6*	*Week- 16*	*Final Exam Question 2*	10
CPL-11 / *PLO-11*	CPMK 5 / *CLO 5*	*Week- 11-15*	*Programming Assignment 3*	5
	CPMK 6 / *CLO 6*	*Week- 8*	*Mid Exam Question 4*	5
		Week- 11-15	*Programming Assignment 3*	5
				∑ = 100%

No	***Form of Assess-ment***	***PLO-01***	***PLO-02***	***PLO-03***	***PLO-04***	***PLO-05***	***PLO-06***	***PLO-07***	***PLO-08***	***PLO-09***	***PLO-10***	***PLO-11***	***PLO-12***	**Total**
1	Tugas 1					0.2								**0.2**

No	*Form of Assess-ment*	*PLO-01*	*PLO-02*	*PLO-03*	*PLO-04*	*PLO-05*	*PLO-06*	*PLO-07*	*PLO-08*	*PLO-09*	*PLO-10*	*PLO-11*	*PLO-12*	Total
	(2 Tugas Pemograman) *Task 1 (2 Programming Assignment)*													
2	Tugas 2 (1 Tugas Pemograman) *Task 2 (1 Programming Assignment)*		0.05			0.05						0.1		**0.2**
3	Evaluasi Tengah Semester (4 Soal) *Mid Term Exam*					0.25						0.05		**0.3**

No	*Form of Assess-ment*	*PLO-01*	*PLO-02*	*PLO-03*	*PLO-04*	*PLO-05*	*PLO-06*	*PLO-07*	*PLO-08*	*PLO-09*	*PLO-10*	*PLO-11*	*PLO-12*	Total
	(4 Questions)													
5	Evaluasi Akhir Semester (3 Soal) *Final Term Exam (3 Questions)*		0.15				0.15							**0.3**
	Total		0.2			0.5						0.15		**1**